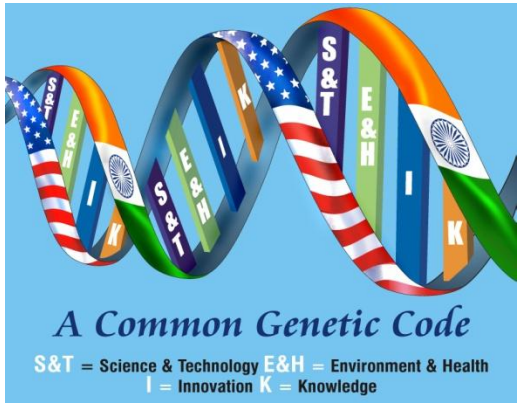
Indo-U.S. Science & Technology Collaboration

- *Opportunities and Challenges*



presented at

Fermi National Accelerator Laboratory Colloquium

October 6, 2010

by

Satish V. Kulkarni

This presentation will cover the following topics

- **India: then to now**
- **India's economic growth**
  - Role of government and public enterprise
  - Role of private enterprise
- **US-India relations**
  - President Obama's visit to India, November 2010
- **US-India collaborations**
  - Higher education
  - S&T
  - Energy and climate change
    - Fermilab/Department of Atomic Energy partnership

India: then to now

- India has a unique position in world history---
- In earlier times, it was a developed nation;
  it downgraded to a developing nation during the past 300 years,
  and is now striving to regain its original status
- With a population of 1.2B, it is the largest functioning democracy,
  a nation of contrasts with a pluralistic, secular society and the
  most diverse mixture of races, religions and languages
- In the past, India was a egalitarian society but over the millennia,
  under foreign occupation, became a highly fragmented, feudal one
  with a compartmentalized caste system.
  Today, the caste system is slowly getting dismantled
  but feudalism persists

India: then to now (cont.)

- **Probably the world's first global university was established in Takshashila (now in Pakistan) in 700BC**
- **Nalanda University followed in 400BC (in the present State of Bihar)**
  - Technology for rustproof and superplastic steel existed during Emperor Ashoka's regime (250BC)
- **In the mid 18th century, India's estimated share of world manufacturing was ~25% and was the largest exporter of goods; today, its share of exports is ~3%**
- **In more recent, pre-independence times, with a very limited S&T infrastructure, India produced scientists like CV Raman, Satyen Bose, Jagdish Bose, Ramanujan, etc…**

Nalanda University, to be re-opened in 2010

CV Raman

Jagdish Bose

Rustproof Iron Pillar

India: then to now (cont.)

- **Rate of population growth is decreasing, but finite resources are beginning to adversely impact per capita availability**
  - Much talk about 'demographic dividend' but there is a flip side to it
- **Literacy/education levels are rising and so are expectations— unemployment/underemployment is perhaps ~30%**
- **Large middle class (~300M) fuels the growth engine and attracts MNCs**
- **India has become the largest milk producing nation (>100M MT in 2007)**
- **India has 69 billionaires with 4 among the world's top 10**
  - Mukesh Ambani is the 'Rockefeller' of India; LN Mittal, 'Carnegie' (Ambani is building a $2B residence in Mumbai)
- **~800M still at or below the poverty line (<$2/day); estimated 1% of the people are crossing that line/year but recent inflation of >10% is negating those gains**
  - There is no evidence of large-scale extreme poverty in the past
- **'Inclusive Growth' is the mantra**

India's economic growth

- **Recently, Indian economy has grown at an annual rate of ~8%**
- **Reasons for this growth**
  - Liberalization of economic policies in 1991 and move away from a stagnant socialist system
  - Many attribute it to 'Jugaad': Entrepreneurship + grassroots innovative approaches to overcome local constraints and obstacles; propensity to improvise
    - Example: Diesel irrigation pump on a steel frame with wheels becomes an 'ultra-cheap' vehicle that does not conform to safety standards
- **There is a downside to this mindset**
  - 'Jugaad' often leads to employing means outside the regulatory framework (at times, illegal) to get the job done
  - 'Sustainable' innovation and 'Scientific' invention suffers
- **For the long-run, need a balanced approach**

India's economic growth- role of government and public enterprise

- **India has a dynamic democracy, generally honest elections and a free and lively media and press**

- **Government and public enterprise have a mixed record**
  - The New Delhi Govt successfully converted all public transportation to CNG fuel, thus significantly improving air quality
  - Preparations for the Commonwealth Games in New Delhi (ongoing) were tainted with cost overruns (~10-100x), corruption and delays

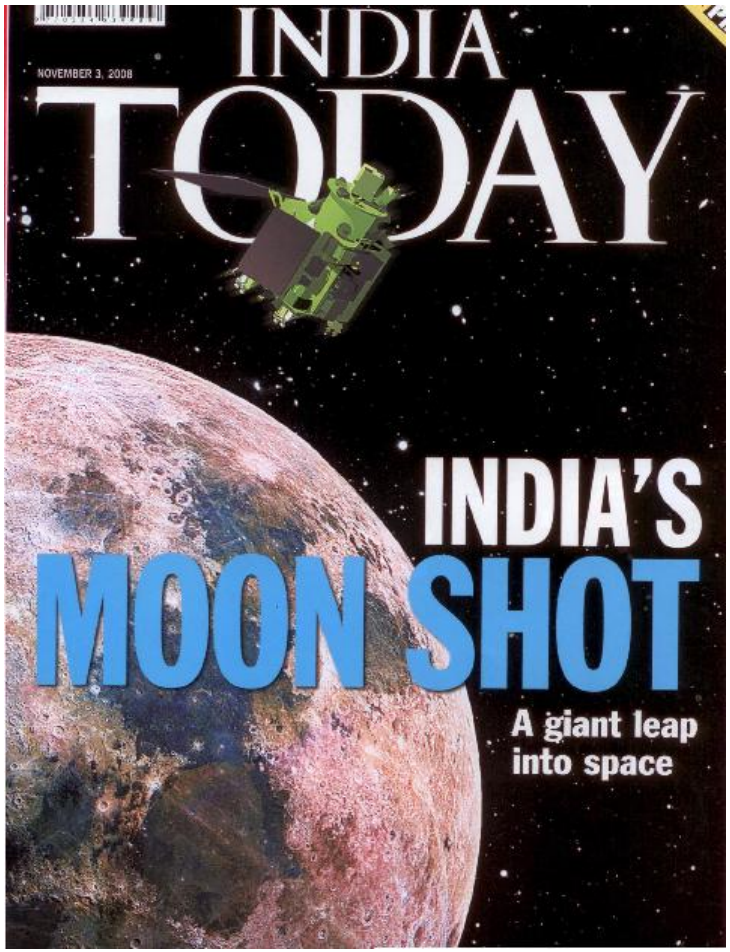
- **Poor governance, infrastructure and delivery of basic services like education, health and sanitation act as a damper**

CNG Buses in New Delhi

India's economic growth- role of government and public enterprise (cont.)

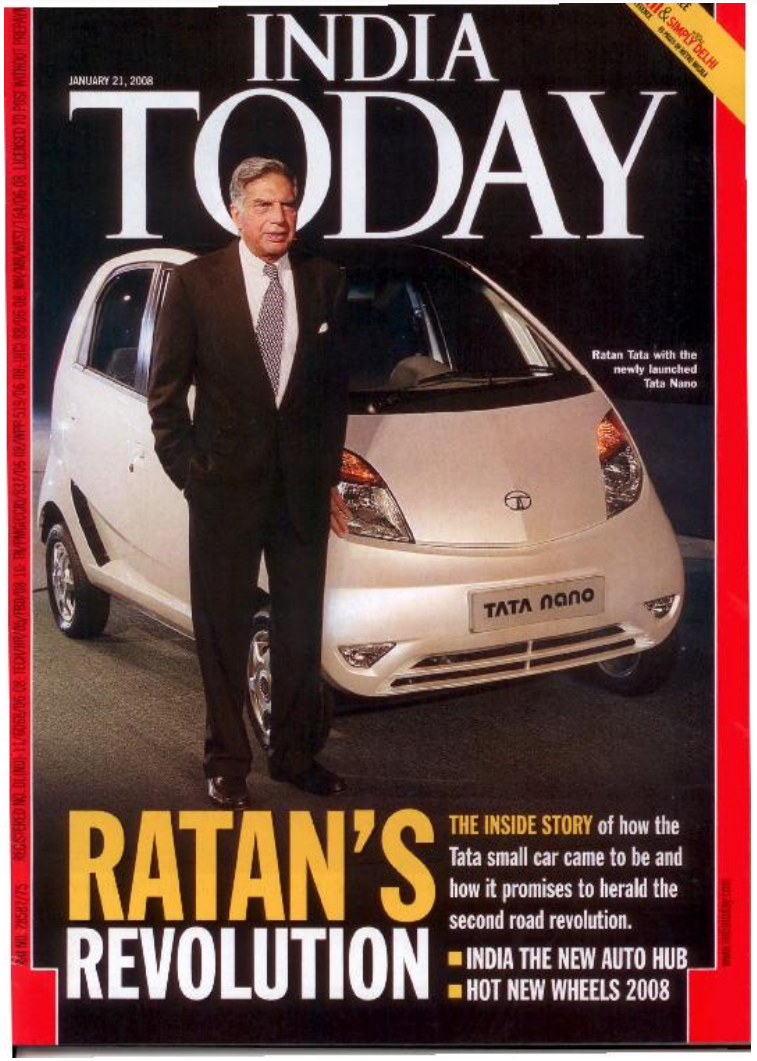
- **India has been successful in developing indigenous nuclear and space programs - albeit with start-up help from the US**
  - Sanctions and technology denials after Pokhran-I Nuclear Test (1974) helped accelerate these developments
  - The US had 2 instruments on India's first Moon Mission, *Chandrayaan-I*

- **However, defense R&D has been plagued with cost overruns and delays**
  - Even with the third largest standing armed forces in the world, India lacks a robust industrial-military infrastructure and 70% of military hardware is imported



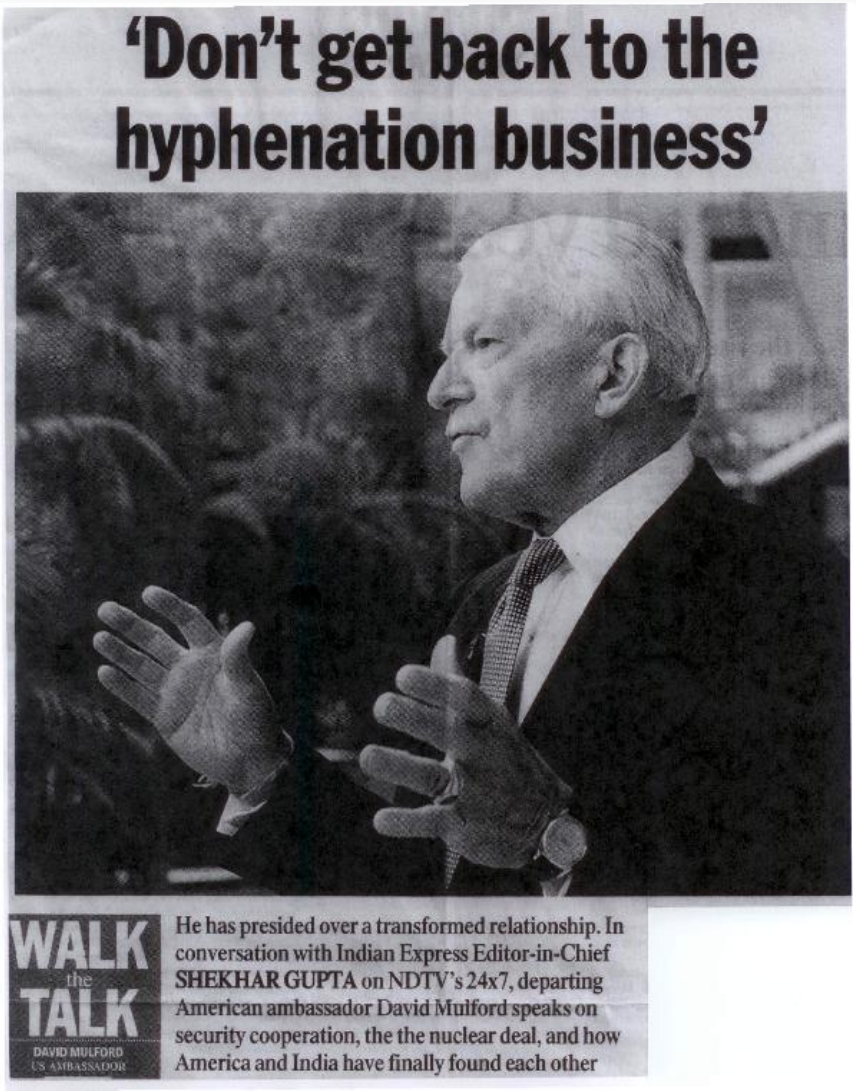
India's economic growth- role of private enterprise

- **India has a vibrant private enterprise**
  - Many global brands (Tata, Reliance, Infosys, Arcelor-Mittal, etc…)
  - A strong biotech-pharma sector
  - In addition to IT, manufacturing is making big gains
    - World's cheapest car: Tata's Nano for ~$2500 (A better example of 'Jugaad')
    - Competitive price points
- **125 Fortune 500 companies have R&D centers in India**
  - Large pool of young talent
- **IBM is the 2nd largest private employer**
  - Just 3 decades ago, it had quit India
- **High-tech industries such as defense, chip manufacturing have lagged because of government policies and poor infrastructure**



US-India relations

- **In-spite of being democracies with similar values, the relationship has been a roller coaster because of cold war politics**
- **Presidents Clinton, Bush and Obama and PMs Vajpayee and Singh have turned this around to a stable strategic partnership**
- **Initially a Development Assistance Model**
  - $14B from 1951-2002
  - Third largest recipient behind Israel and Egypt
- **PL-480**
  - Generated ~$3B in rupees from food assistance not to be converted to $s
  - $2B forgiven, $990M (almost) spent
    - **Green Revolution** and **IIT Kanpur** are the showcase icons
- **Transformation from a Donor-Recipient to a Partnership Model**



Five principal pillars of US-India relations

- Strategic Cooperation
- Energy and Climate Change
-
- Education and Development
- Economics, Trade and Agriculture
- Science, Technology, Health and Innovation

President Obama visiting India in early November 2010

India's Eleventh Five Year Plan (2007-2012)

- **Investment**
  - Overall increase of 400% from 10th to 11th Plan
  - Nine-fold increase in higher education outlays
  - Increase R&D expenditures from 0.8% to 1.3% of GDP
  - Funding for basic science to triple from current level of ~$500M

India's Eleventh Five Year Plan (cont.)

- **Human Resource Development**
  - Investment of $8.4B to double India's higher education enrollment; build new institutions on existing models
    - Central Universities: from 18 to 48 incl.14 Innovation Universities
    - IISER: from 3 to 8
    - IIT: from 7 to 15
    - NIPER: from 1 to 7
    - IIIT: from 4 to 24
    - IIM: from 7 to 14
  - Substantial increases in faculty and scientist salaries

US and India face similar challenges in S&T education and research

US Challenges

(*Rising Above the Gathering Storm*, National Academies report, Chair: Norm Augustine)

- ❑ Science and innovation in stall or decline (100% surveyed)
- ❑ Need 10,000 teachers, 10 million minds, K-12 science and math education
- ❑ Sow the seeds for the future through science and engineering (SE) higher education
- ❑ Best and brightest needed in SE higher education
- ❑ Disinvestment in the future-erosion of corporate R&D
- ❑ Incentives for innovation lacking
- ❑ Perception that world is not flat but tilted
- ❑ Reaction to 9/11-visa policies

India's Challenges

(*PM's Science Advisory Council*, Chair:CNR Rao;

National Knowledge Commission, Chair: Sam Pitroda)

- ❑Rate of growth of Indian science slowed down considerably
- ❑Quantity has overtaken quality in education; lack of good faculty
- ❑Low interest in science-unattractive career prospects
- ❑Lack of peer review and transparency
- ❑Low investment in corporate R&D
- ❑Human capital good for the world (feeder mentality) but not much indigenous IP (innovation)
- ❑Unshackle science from bureaucracy

Current challenges (cont.)

- Large number of students in science and engineering, but relatively few PhDs (< Brazil)
- Large number of ‘Deemed’ Universities with questionable infrastructure
- Corrupt accreditation processes
- Quality, not funding, is the constraint

- Steps are being taken to reform the system

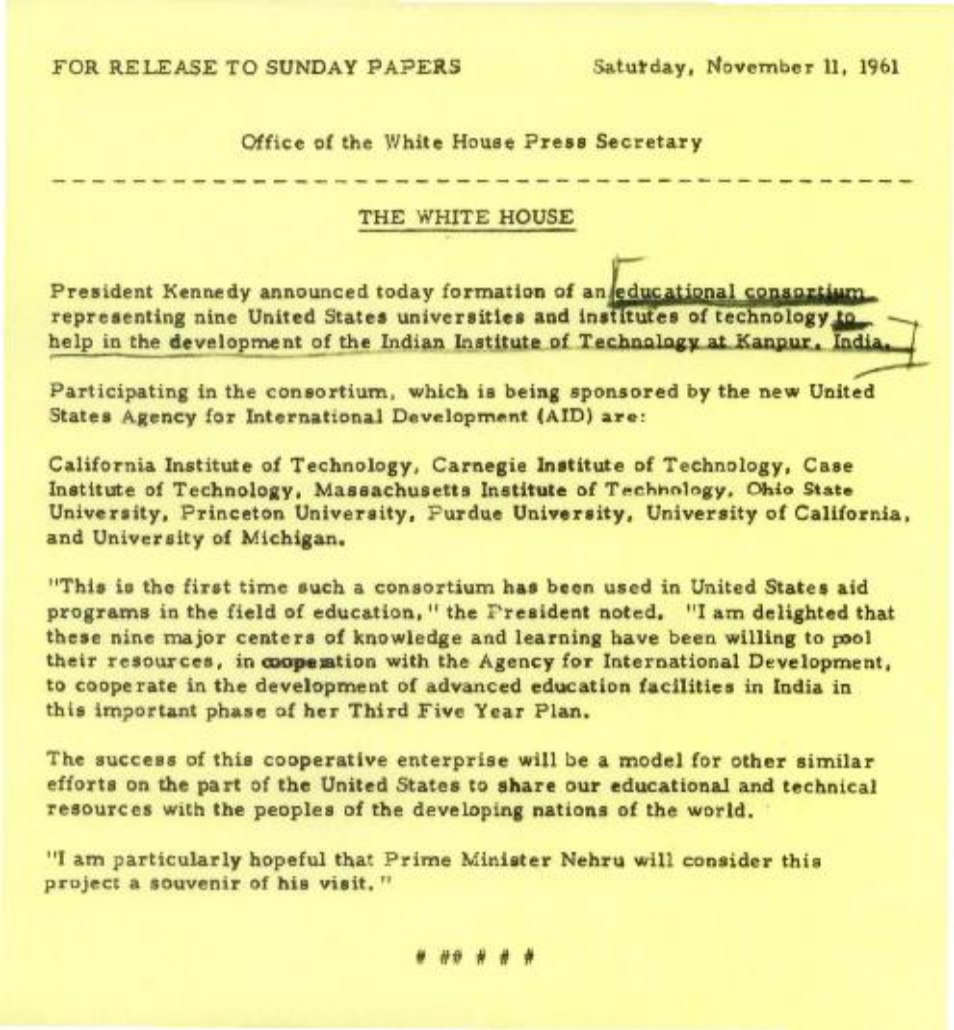
US-India partnership in higher education

- **From 1961-1972, the Kanpur Indo-American Program (KIAP) for IIT Kanpur was one of the largest USAID programs ever for higher education.**
  In collaboration with 9 US Univs/ASEE, innovative concepts in engineering education were introduced
  - -Semester system,
    science-based engineering,
    first computer science course in India

- **Fulbright-Nehru Fellowships**

- **Today, India is again seeking partnerships with US Univs to help establish its 14 'Innovation' Universities**
  - -India's Education Minister Sibal's visit to the US in October, 2009

- **Many US Univs are actively exploring presence in India by partnering with local institutions**



FOR RELEASE TO SUNDAY PAPERS Saturday, November 11, 1961

Office of the White House Press Secretary

THE WHITE HOUSE

President Kennedy announced today formation of an educational consortium representing nine United States universities and institutes of technology to help in the development of the Indian Institute of Technology at Kanpur, India.

Participating in the consortium, which is being sponsored by the new United States Agency for International Development (AID) are:

California Institute of Technology, Carnegie Institute of Technology, Case Institute of Technology, Massachusetts Institute of Technology, Ohio State University, Princeton University, Purdue University, University of California, and University of Michigan.

"This is the first time such a consortium has been used in United States aid programs in the field of education," the President noted. "I am delighted that these nine major centers of knowledge and learning have been willing to pool their resources, in cooperation with the Agency for International Development, to cooperate in the development of advanced education facilities in India in this important phase of her Third Five Year Plan.

The success of this cooperative enterprise will be a model for other similar efforts on the part of the United States to share our educational and technical resources with the peoples of the developing nations of the world.

"I am particularly hopeful that Prime Minister Nehru will consider this project a souvenir of his visit."

#

Some stats…of IIT Alumni in the US

- 50,000+ IIT Alumni call USA ‘Home’
- 850+ identified CEOs in USA are IIT Alumni
- 60% of Silicon Valley start-ups are estimated to contain at least one IIT Alumnus as a ‘founder’
- Estimated wealth generated by IIT Alumni in USA based on market cap: $50 Billion+
- Estimated number of jobs created by IIT Alumni in USA: 200,000

US-India S&T collaborations

- **At last count (2008), India had ~75 bilateral S&T Agreements**
- **S&T collaborations have occurred along different tracks**
  - Indian Diaspora, people-to-people
  - PL-480 (US India Fund)
    - Focused effort till 1974, but later very ad-hoc and tactical
    - More strategic since 2005
  - Bilateral activities: NSF, NIH, NASA, NOAA, EPA with their Indian counterparts
  - Multilateral partnership: ITER, Thirty Meter Telescope (TMT) Project
  - Agricultural Knowledge Initiative (Evergreen Revolution)
- **Strategic partnership opened up new avenues**
  - Energy Dialog
  - High Technology Cooperation Group (Dept of Commerce)
  - Defense and Counter Terrorism
  - CEO Forum
  - US India Business Council

US-India S&T collaborations (cont.)

- **Indo-US S&T Forum (IUSSTF) (2000)**

CATALYST to *facilitate, seed and promote* US-India bilateral collaboration in science, technology, engineering and biomedical research through substantive interaction among government, academia and industry

--Endowment from PL-480 rupees (~$7.5M equivalent);

GOI matches interest on this endowment; 2009 budget: $4 million equivalent

-- Award to Fermilab and Delhi Univ for "Accelerators and Detectors for Future High Energy Physics Experiments Virtual Center", 2010

- **Indo-US S&T Agreement (2005)**

Agreement to allow a wide range of scientific and technical cooperation between the scientific enterprises of the two countries and establish for the first time the intellectual property rights protocols

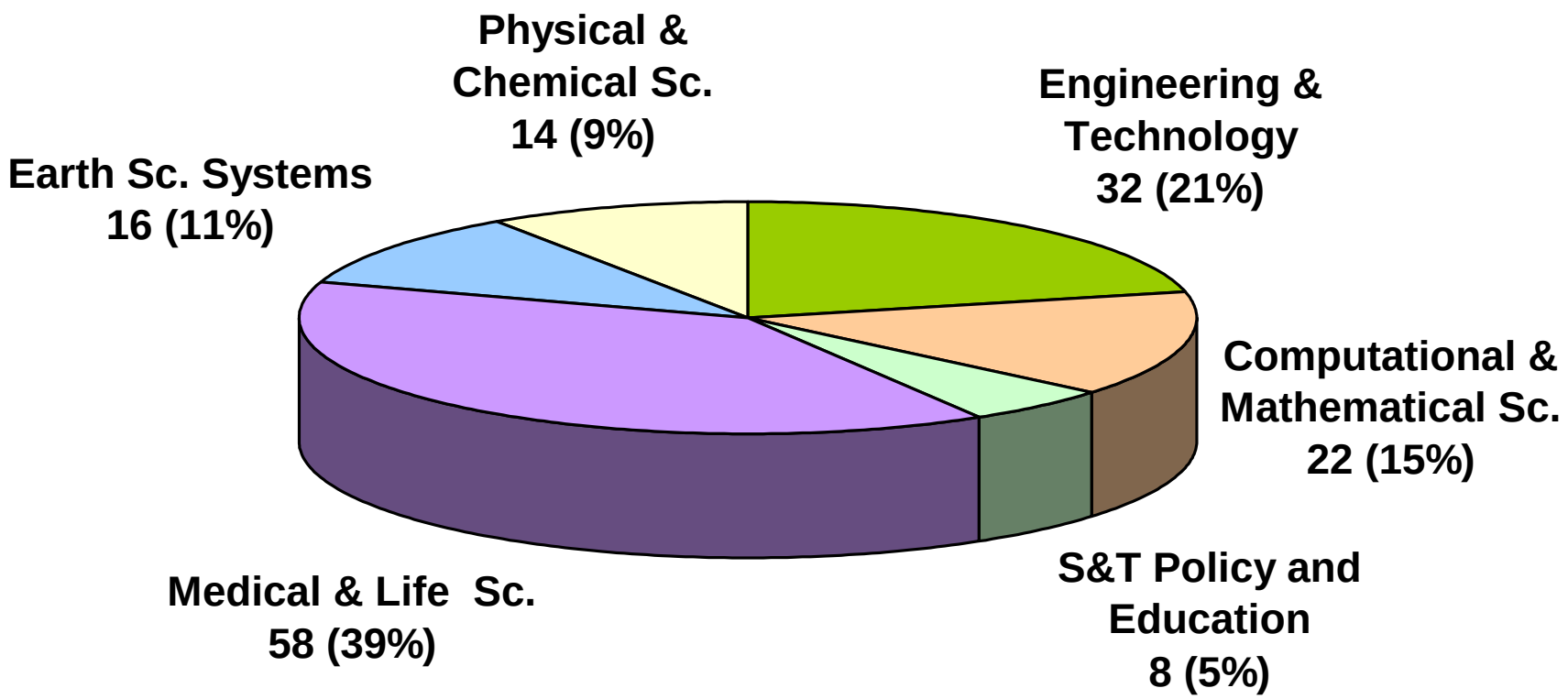
- **Indo-US Endowment for Joint R&D, Innovation, Entrepreneurial and Commercialization Activities in S&T (2009)**

--Endowment from remaining PL-480 rupees (~$15M equivalent);

GOI matches interest on this endowment

- **US-India Joint Commission on S&T Cooperation (2010)**
  - OSTP's Dr. John Holdren and India's S&T Minister Co-Chairs

IUSSTF cutting across disciplines



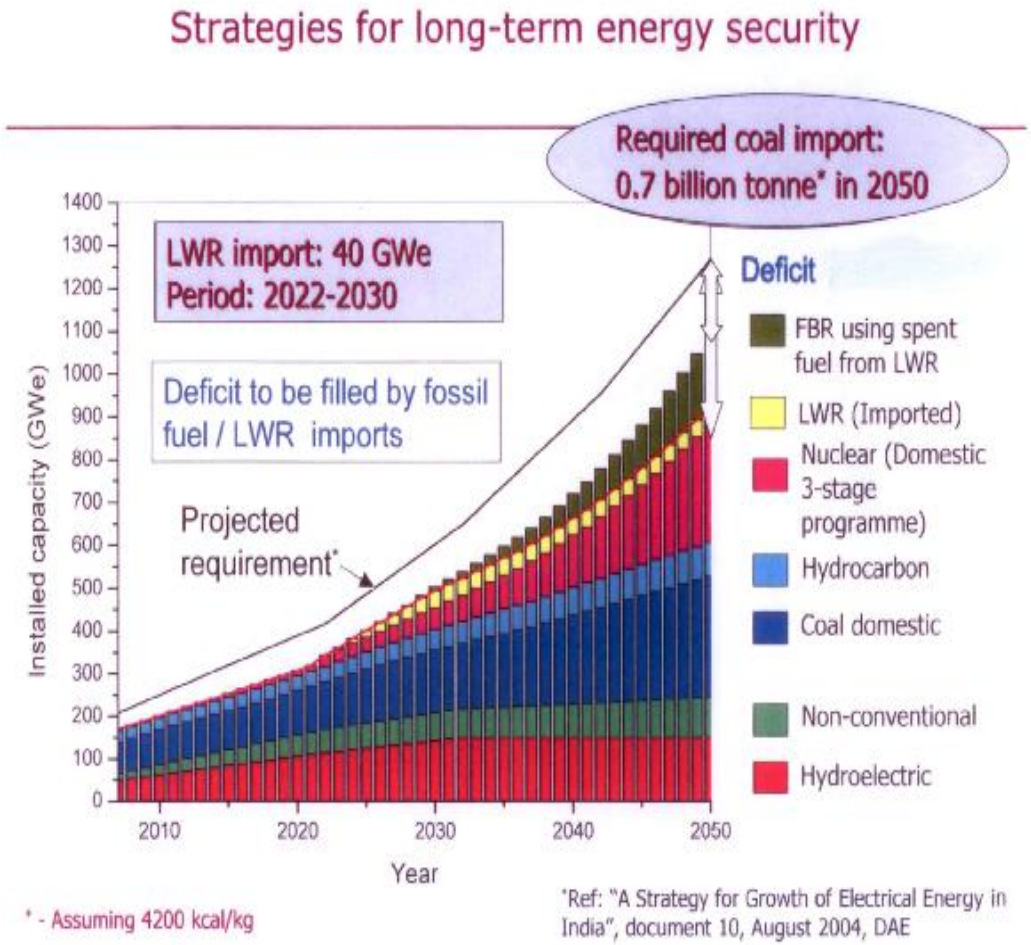
Ref: Dr. M. Cheetham, IUSSTF

Current challenges

- **US and India have different operating styles**
  - Bottom up *vs* top down
  - 2nd level leadership has little (or no) authority in Indian institutions
- **Ineffective implementation of program plans**
- **Lack of qualified PIs**
  - ~40% of R&D budget has remained unspent in recent years
- **Asymmetric capabilities for a partnership model to succeed**
- **Modalities of recent agreements/partnerships being worked out**
  - Fermilab/Dept of Atomic Energy model could be emulated
- **Inadequate university-national laboratories interactions**
- **Insufficient funding and/or funding cuts (e.g., ITER) in the US**
- **Visa problems (US) and retaliatory measures (India)**

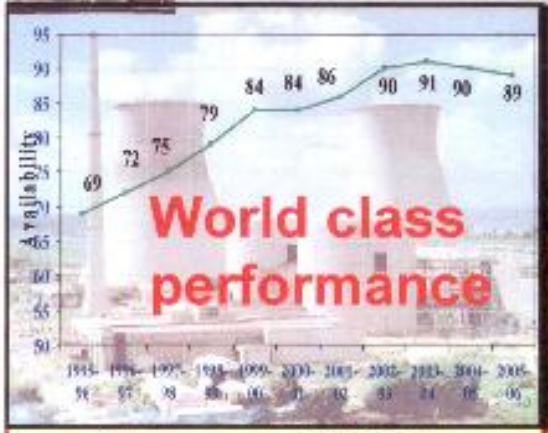
India's energy challenge

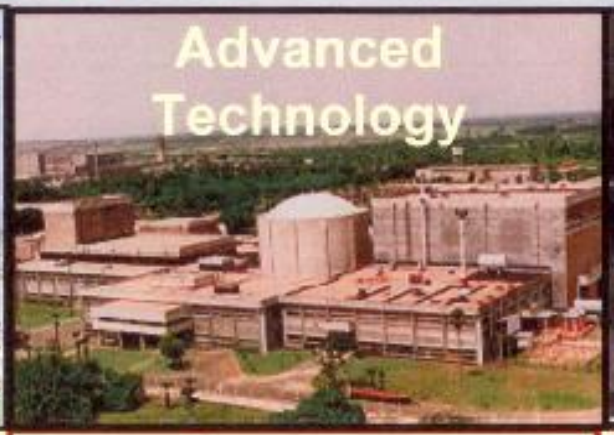
- ~ 50% of population without access to electricity;
  ~ 70% of households use traditional biomass for cooking
- Over 40% of households have no consistent supply of commercial energy, even for lighting
- Total installed capacity: ~165GWe;
  Nuclear: ~3%
- Hydrocarbon reserves (extractable coal, oil, gas) not expected to last beyond this century

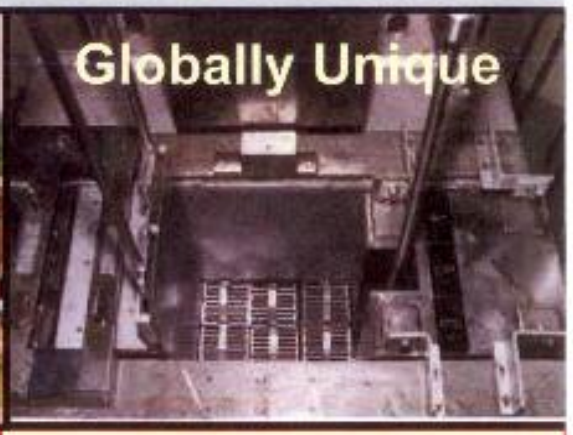


BARC

Three Stage Nuclear Power Programme







Stage – I PHWRs

- 15 – Operating
- 3 - Under construction
- Several others planned
- Scaling to 700 MWe
- Gestation period has been reduced
- POWER POTENTIAL ≅ 10,000 MWe

LWRs

- 2 BWRs Operating
- 2 VVERs under construction

Stage - II

Fast Breeder Reactors

- 40 MWth FBTR - Operating since 1985
- Technology Objectives realised
- 500 MWe PFBR- Under Construction
- POWER POTENTIAL ≅ 530,000 MWe

Stage - III

Thorium Based Reactors

- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Under Development

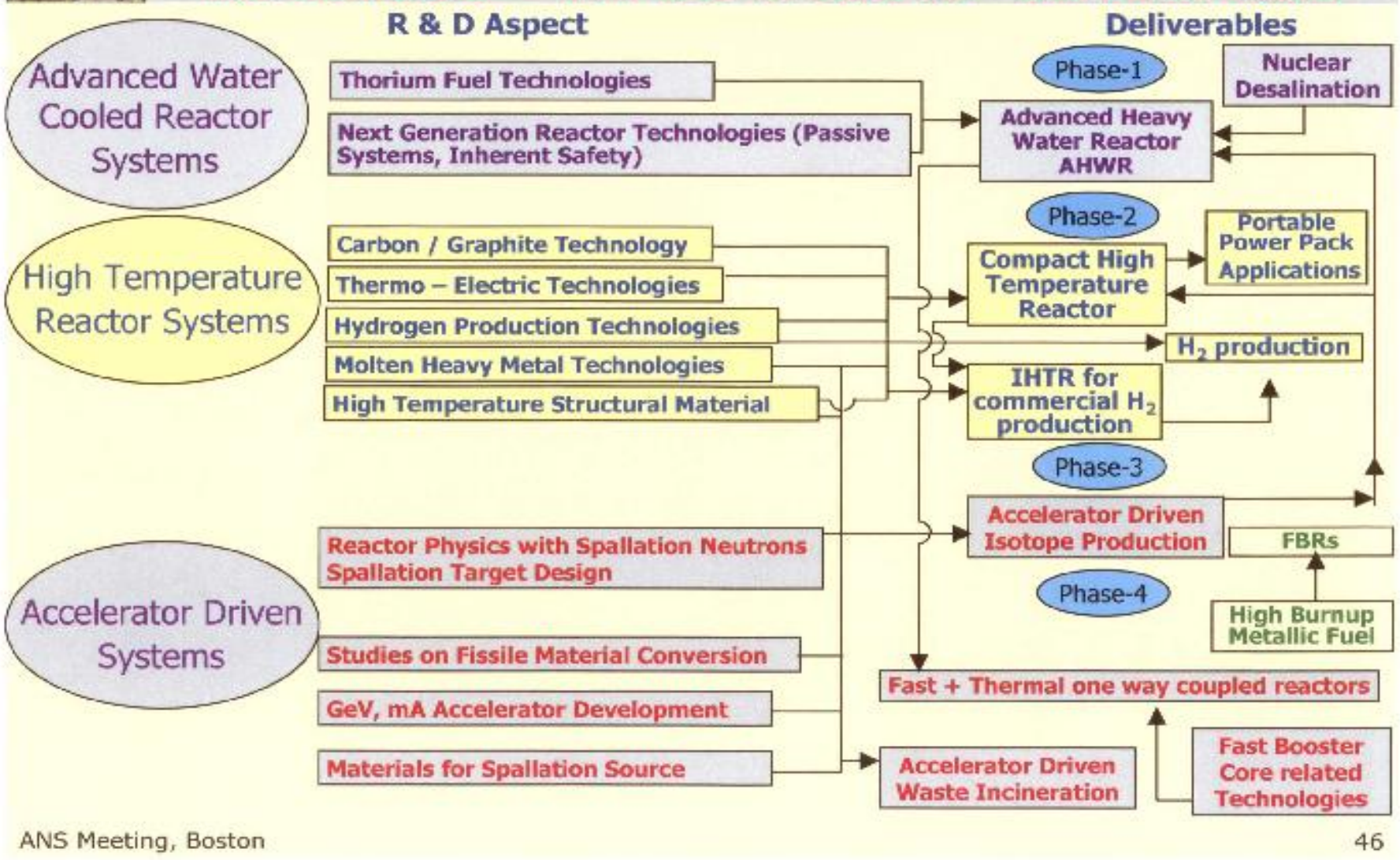
POWER POTENTIAL IS VERY LARGE

Availability of ADS can enable early introduction of Thorium on a large scale

Ref: Dr. S. Banerjee , Secretary, DAE

BARC

Roadmap for Utilisation of Thorium Resources – Thrust areas for current R&D



Ref: Dr. S. Banerjee , Secretary, DAE

US-India energy partnerships

- **Indo-US Civil Nuclear Agreement**
  (Hyde Act, 123 Agreement, IAEA Safeguards, NSG Waiver, Reprocessing Agreement, Nuclear Liability Bill/Convention on Supplementary Compensation**), 2005-2010**

- **Fermilab/Department of Atomic Energy MOU for Particle Accelerator Technology and High Energy Physics, 2006**

- **American and Indian Nuclear Societies MOU, 2007**

- **Invitation to participate in 'Science at the National Ignition Facility' at Livermore Lab, 2008**

- **US Nuclear Engineering Dept Heads Organization (NEDHO) Agreement**
  (Collaboration with Indian institutions in the education, research and training in nuclear engineering**), 2009**

- **Agreement for Cooperation on a Joint Clean Energy R&D Center, 2010**

Fermilab and India's strategies for accelerator development for the next 10 yrs are aligned

- **For Fermilab, a multi-MW Proton Source, Project X, is the centerpiece of its strategy for future development of the accelerator complex**
- **For India, a similar Proton Source to drive a subcritical reactor will 'accelerate' the introduction of Thorium in its 3-Stage Nuclear Power Program**
- **The High Intensity Proton Accelerator (HIPA) with SRF Linac technology is being developed at Fermilab as a national project with international partners**
  - India is the first partner
- **This is an unprecedented opportunity to leverage capabilities and resources**

The climate change conundrum

- **While US and India have been in different camps on the Kyoto Protocol, India has been a key participant in recent US-led initiatives**
  - The 7-nation Asia-Pacific Partnership for Clean Development (US, India, China, S Korea, Japan, Australia and Canada)
  - Major Economies Meetings leading up to the UN Framework Convention on Climate Change (UNFCC) Conference of Parties (COP) in December, 2009 in Copenhagen
- **India's position, collaborations with US**
  - India's per capita GHG emissions are 1/20th of US but ranks 4th in total emissions
    - There is a rethink on playing the per capita card
  - Developed countries should do more
    - Blame it on the Industrial Revolution beginning 1750 (with no acknowledgement of its benefits to developing nations!!)
  - Common but 'differentiated' response
    - Only aspirational caps on GHG emissions
    - Strike a balance between decreasing emissions and decreasing poverty
  - Clean tech transfer at little or no cost to developing countries
  - India's Climate Change Action Plan is focused on solar energy and energy efficiency
  - MOU between NOAA and Indian Meteorological Dept on Modeling of Monsoon
  - Greater cooperation needed in climate modeling/prediction and adaptation strategies
- **Green jobs is a highly politicized issue today in the US-China-India space**

Some closing thoughts

- **Attributes for a successful S&T collaboration with India---**

- Partnerships should be leveraged and mutually beneficial
  - Essential in times of funding constraints
- Need a champion, not just an Agreement or MOU
- Address the challenges of today
  - Energy security, climate change, water security, environment, public health
    - Emphasize sustainable innovation
  - S&T should also address rural needs and benefit the poor
- Patience and perseverance

- **As a developing nation, India has a vast reservoir of potential energy; it needs to be converted to kinetic energy without damping losses**

An Enduring Strategic Partnership